standards for raw water and most finished water sampling points i.e. the 0.2 ppm level. Now as to the specific pesticides, positive values were reported at at least one sampling point for each of the years tests were conducted. The last detectable residue in finished water was in May, 1963. The overall picture of pesticide residues reported in this area is as follows: chlorinated hydrocarbons, undetectable by analytical methods sensitive to 0.1 ppb as lindane; and for organic phosphorus compounds, reported as parathion, these were present at a detection level of 0.045 ppb. This is well below the allowable level for this class of compound in water. In 1969 and 1970, pesticides of the chlorinated hydrocarbon class were detected in finished water at levels up to 0.002 ppm. Surveillance of this supply is continuing from 1971 through a contract with a private laboratory to do monthly screening tests on raw and finished water.

SUMMARY AND CONCLUSION

Table 1 shows the present allowable limits for specific economic poisons in water. At this time we have a statewide support capability of three operational laboratories directing their efforts to potable water supplies: Brevard County Health Department, Tampa Water Plant, and Department of Pollution Control (Winter Haven).

To clarify the status of "pesticide" chemicals in the State of Florida, as of the date of this presentation, there is only one which has an allowable level in potable water. That chemical is copper. The current recommended maximum limit, as set by the Drinking Water Standards, is 1.0 ppm.

With reference to other products, you can check those listed in the table. The general, yet unofficial, rule for Florida is that none of these levels shall be exceeded where any raw water sources are involved, and suitable analytical techniques must be available for the detection of the stated residue levels in that water. There must also be a referee laboratory engaged or participating in any intentional addition of chemicals to a water supply source.

A product must be registered with both the Federal and State Regulatory Offices. The Department of Natural Resources has the assigned responsibility for the application of herbicides under the Florida Aquatic Weed Control Act of 1970. They have published a booklet "Guidelines for Aquatic Weed Control" (January, 1972) which presents established procedures or policies in areas of aquatic weed control.

In conclusion, the impact of pesticide chemicals in our potable water supply is expected to be one of chronic and low level exposure over a period of many years. Acute poisoning cases in man are not probable as a result of drinking water from a public water supply system receiving either intentional or indirect residue levels of economic poisons. This is especially true when the commercial product is used as directed. Hence, we are faced with a nonspectacular threat which the man on the street neither feels nor understands. It is even hard for us in the business to get too excited over things we cannot see, smell, or feel and therefore tend to forget them or put them aside until they cause us trouble. We must not allow these common tendencies to result in the failure to provide routine surveillance of residue levels of toxic chemicals in the water we drink. In conclusion, all of us who drink water have a personal interest and should support necessary control and surveillance programs. Water is essential to our life and health. Let us protect it!

Aquatic Plant Problems in the Walla Walla District

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ABSTRACT

The Walla Walla District, Corps of Engineers, maintains some 21 miles of drainage ditches behind the Tri-City Levees (Kennewick-Pasco-Richland, Washington) of Lake Wallula. The ditches drain water from both residential and farming lands. Drainage water is discharged into the Columbia River, which supports an important anadromous fishery. The resulting aquatic weed problem prompted the Corps to initiate a program to find a chemical which would control the aquatic weeds and still be compatible with fish life. Treatment with 6,7-dihydrodipyrido (1,2-*a*:2′,1′-c)-pyrazinediium dibromide (diquat) was found to be satisfactory for the conditions present. Diquat was used at the rate of 1.0 gal./cfs for a 20-min exposure. This was equivalent to 26 ppm of chemical.

INTRODUCTION

With the completion of McNary Dam in 1954 and the raising of the McNary pool, it was necessary to construct some 21 miles of drainage ditches in the Tri-City area to drain the lowlands behind the levees. Of these 21 miles of ditches, 10 miles are for inland drainage and 11 miles for levee drainage. It was necessary to install 15 pumping plants in this Tri-City area to lift waste water and treated sewage over the protective levees. Maintaining a specific water table behind each levee is dependent upon the action of the pumps in returning water to the reservoir. Water table evaluation is very critical, when the table gets too high crop damage results; when it gets too low, it may cause well failures. As the mouths of these drainage ditches are all considerably lower than the water table in McNary pool, almost constant pumping is required to lift this water from these ditches, over the dikes, and into the main stem of the Columbia River.

Principal aquatic plants found in this area are sago pondweed (*Potamogeton pectinatus* L.), curly leaf pondweed (*Potamogeton crispis* L.), speedwell (*Veronica* spp.), and common duckweed (*Lemna minor* L.). Mechanical control of these aquatic weeds was inefficient and laborious. Lack of access roads to many of the ditches made maintenance difficult. In areas that were inaccessible for mobile equipment, a team of horses was used to drag a chain down the ditch to tear the weeds loose. The loosened weeds would then float down the ditch to the pumping plant where they were removed with a clamshell bucket, and by hand labor, using pitchforks. Following construction of access roads, a tractor equipped with a side boom was used to drag a chain down the ditch for loosening the weeds. As time progressed, a 20 ft rake was fabricated which was handled by a crane in the same manner as a dragline bucket. This method, too, was slow and expensive due to the labor required.

The mechanical method was improved upon by the use of three-isomer xylene (socal), a liquid aromatic petroleum product administered directly into the water. This chemical had a burning effect on the aquatic growth, causing the portion of the weed above ground to slough off. The root was not affected; therefore, repeated treatments were necessary, about every 4 weeks. The chemical was easy to apply and one man could treat all the ditches in approximately 3 days. A sprayer with a 300 gal tank was used for injecting the chemical into the stream. Socal is refined with the highest aromatic content possible to give optimum kill, and was used successfully for aquatic weed control. However, because this water is pumped into the main stem of the Columbia River, the Washington State Pollution Commission, along with the state and Federal fishery agencies, requested that the Corps of Engineers seek other nontoxic chemicals for treating aquatic vegetation.

A meeting was held in January 1967 in which representatives of the U.S. Army Corps of Engineers, Federal Pollution Control Agency, State of Washington Pollution Commission, State of Washington Fish and Game Department and the Bureau of Sports Fisheries and Wildlife Division of solution for aquatic weed control. Water quality data of the test areas are given in Table 1. Herbicides considered were among those listed in the Weed Science Society Handbook (4). These herbicides have been under

TABLE 1. WATER QUALITY OF TEST AREAS

TEST AREA	pH	Alkalinity (ppm)	Conductivity (μmhos)	Magnesium (ppm)	$CaCO_3$ (ppm)
Drain A	7.9	260	475	60	200
Drain B	7.7	200	200	60	150
Levee 12-1	7.8	150	259	30	190
Heddington	7.4	240	249	100	180

research study for a number of years (2). Related studies of diquat are published by Gilderhus (1), Yeo (5), and Surber and Pickering (3).

METHODS AND MATERIALS

For this study, drainage ditches 12-1 and 12-2 in the Pasco area were treated with a socal-diquat combination for control of aquatic weeds (Figure 1). Fish (4 to 5-inch rainbow trout) were placed in the ditches approximately 20 ft from the discharge pump intakes 24 hr before the test date. This was to allow the fish to become accustomed to the change in water quality and to eliminate any mortalities before the test.

One and two-tenths miles of drain 12-1 were tested, the application being 2 gal socal per cfs and 1.0 gal of diquat per cfs, the flow of water being 20 cfs. Xylene plus 1.5% of emulsifier (ADH-10) was injected into the water through a small orifice under 75 psi for a period of 30 minutes. Diquat was slowly poured into the water over a BJ-bin period. Water temperature at drain 12-1 was 50 F. The water was clear with a moderately heavy growth of aquatic plants. The most prevalent aquatic weeds were sago pondweed and speedwell.

The fish traps in drains 12-1 and 12-2 were examined following the complete discharge (4 hr) of the chemicals from the drainage ditches. All the fish in drain 12-2 were dead, excluding the future use of socal. Drain 12-1 empties into a 10 acre pond before being discharged into the Columbia River. All the fish survived this treatment due to the diluting effect of the ponding area before discharge. The fish were held for a period of 23 hr and were alive after this period and were released.

Eighteen hours after treating ditches 12-1 and 12-2 with the socal-diquat combination, the speedwell had turned brown and was flattened on the ditch bottom. This plant was turning soft and small sections were breaking off and disintegrating in the flowing water. After 3 weeks speedwell and sago pondweed were completely killed.

Drainage ditch 5-D in Kennewick was treated with 1 gal of diquat per cfs (10 cfs flow). The action was slower than with the socal-diquat combination, but the results were very satisfactory. This ditch required only two treatments during the entire summer, demonstrating a slower reaction with diquat alone, but a longer sustained inhibition of plant growth. The amount of chemical used was equal to 26.7 ppm in the flowing water. The scrap fish in the drainage ditch (mainly carp and suckers) would avoid the chemical when possible, but no adverse effects were noted. Rainbow trout held in the trap at the pump intake did

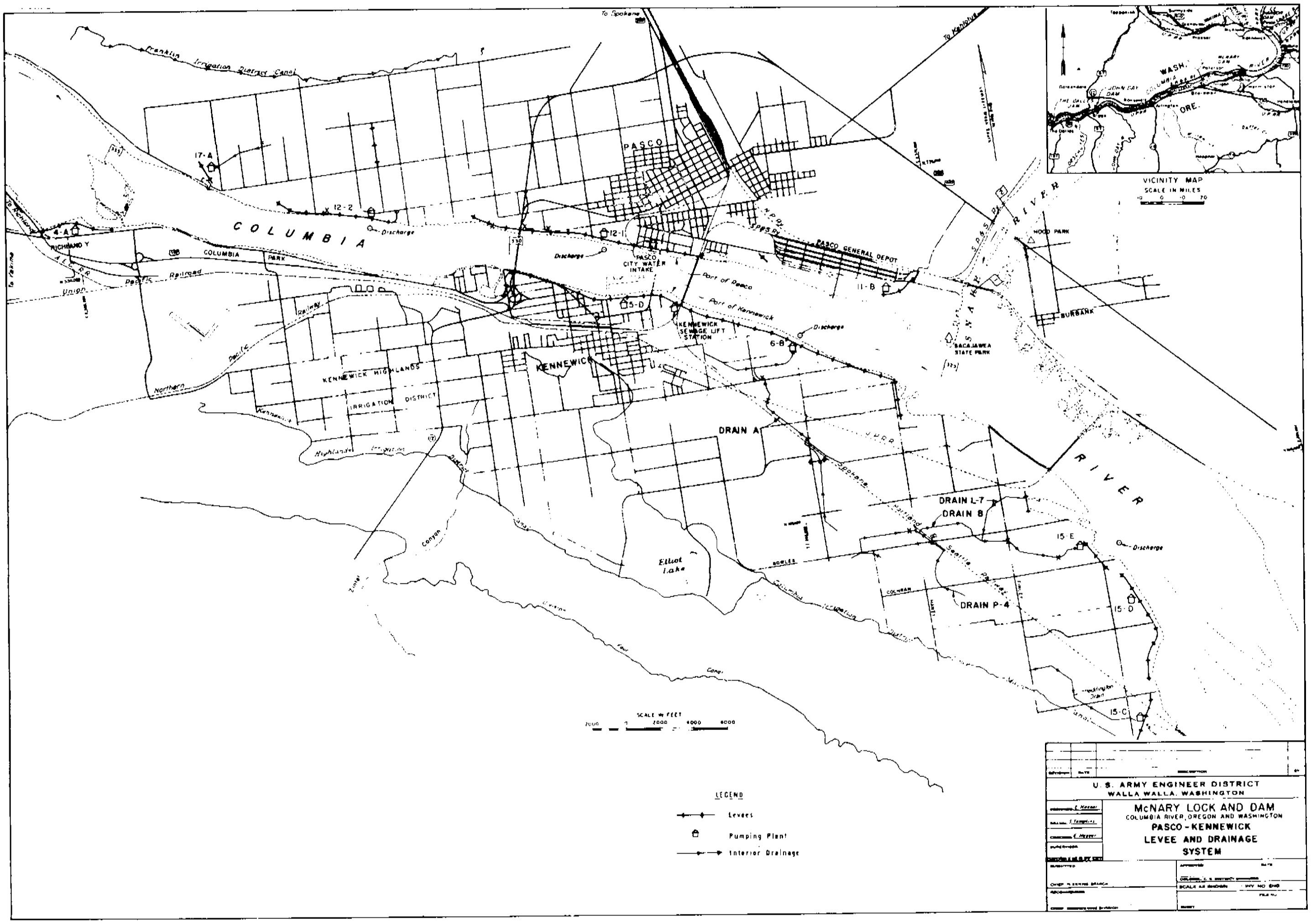

Figure 1. Pasco-Kennewick levee and drainage system in the Walla Walla U.S. Army Engineer District, Washington.

not display any reaction to the chemical and were released at the end of 24 hr.

For control of emergent weeds along the waterline, some of the drainage ditches were sprayed with diquat and 2,4-dichlorophenoxy) acetic acid (2, 4-D). The bank weeds consisted of various grasses, Russian thistle (*Salsola kali* L. var tenuifolia), curlydock (*Rumex crispus* L.) and speedwell. In areas of lush foliage, two or more applications were necessary for control. The first spraying was accomplished using a hand-type sprayer. Later, a boom-type sprayer was developed for this work which greatly increased the efficiency of the operation.

Aquatic weed control drainage ditch 15-D was treated with 2,6-dichlorobenzonitrile (dichlobenil) at a rate of 150 lb/acre. This granular chemical was applied with a hand spreader, the granules being scattered over the water surface and approximately 5 ft up the ditch bank above the water's edge.

This area of application was in a slow flowing drainage ditch with approximately 3 to 4 cfs and containing a moderate growth of aquatic plants. Most of the plants were holdovers from the 1966 season which did not die out during the mild winter. These plants were sago pondweed, and speedwell. One week following the chemical treating of drain 15-D, areas of drain A suitable for dichlobenil were treated at the rate of 200 lb/acre. This chemical is slow in reacting on plants which are in a growth stage. The first indication of chemical action is the change in coloration of the plants. Upon breaking a plant stem, the inner phloem layer will have turned brown. This area of degeneration is very soft and gives the appearance of plant cells undergoing autolysis. The action of this chemical on aquatic weeds was very effective.

Young steelhead (*Salmo gairdneri*) 5 to 6 inches in length were used in the dichlobenil experiment. Twenty-four hr before applying the chemical, three baskets were placed in the ditch upstream of the pump intake approximately 20 ft apart. Therefore, all treated water flowed over the baskets before being discharged into the Columbia River. Each of the baskets contained 16 fish. All fish were alive and showed no signs of distress on the treatment date. Following treatment all fish were alive and active after a 26-hr exposure period and were released into the river at this time.

Hydrothol 191

The first application of mono (N, N-dimethylalkylamine) sale of 7-oxabicyclo [2.2.1] heptane-2-3-dicarboxylic acid (hydrothol 191) was in drain B, just north of the SP&S Railroad tracks (Figure 1). A 1:1 mixture of hydrothol 191 and water was placed in a 50-gal drum equipped with a constant flow regulator. This was set to discharge at the rate of 32 oz/min which approximated 5 ppm at the point of injection (flow of water at this point was approximately 15 cfs).

Another area of application was 0.5 mile west of Haney Road on drain B. The quantity of water was estimated at 5 cfs and flowing quite slowly. Hydrothol 191 was applied directly from the 5-gal cans over a period of 1 hr and 40 min. This was somewhat faster than desired as specifications call for at least a 2-hr exposure time. This was an area of low flow in which mixing the chemical with water to double the overall quantity would have increased the accuracy of delivery and by extending the exposure time may have produced more significant results on the aquatic vegetation. The concentration of Hydrothol 191 in the water was equal to 12 ppm at the point of application. This quantity of Hydrothol 191 was necessary due to the increase of flow to 10 cfs between the points of application.

After 10 days the plants were browning and the sago pondweed was breaking off and floating downstream. The algae showed very little change. At the end of 20 days the aquatic plants had completely recovered.

The main stem of drain A was treated with 15 gal of Hydrothol 191 at the rate of 6 oz/min over a 7-hr period, flow being 33 cfs. This gave a concentration of 6 ppm, which was somewhat toxic to the fish at the pump intake. Eight out of 24 fish died, giving a 75% survival.

2,4-D plus silvex

A granular preparation of 2,4-D acid with a 10% acid equivalent (a.i.) plus 2- (2,4.5-trichlorophenoxy) propionic acid (silvex) (a.i. 2%) was applied to the Heddington Drain; the chemical application covered an area 8 ft wide and 2,640 ft long. Application of the chemical was started at the headwaters of the drain. The area treated has a heavy concentration of algae, sago pondweed, and speedwell. The recommended rate of application on new growth in a ditch or pond is 200 lb/acre, 250 lb for old growth weeds. Due to the rough terrain along the ditch banks, it was very difficult to walk at a steady pace, making a uniform application almost impossible in this particular ditch area; therefore, the first ditch section received the equivalent of 500 lb/acre. Application was made with a hand spreader, the same as used for dichlobenil.

A total of 6,178 ft of drain 12-2 on the Pasco side of the Columbia River was treated with 920 lb of the 2,4-D plus silvex granules. Examination of the treated areas after 12 days showed that the chemical was affecting the broadleaf plant speedwell. There was no effect on the algae or sago pondweed at the end of 12 days. At the end of 30 days the areas were again examined. In drain 12-2, the old speedwell plants were cleaned out and new plants were starting to emerge. The Heddington Drain was choked with algae. The ingredients in 2,4-D plus silvex granules have been proven nontoxic to warm-blooded animals, fish, and aquatic organisms in the concentration recommended.

CONCLUSION

After testing the various herbicides throughout the drainage systems in the Tri-Cities, Washington area, diquat was effective in all phases of application to all the noxious plants which infest the drainage system in the area.

Diquat can be used directly in the flowing stream or in combination with socal. It can be used in a 2% solution to spray ditchbank weeds and also over water surface to control algae. Spraying for algae must be carried out every 2 weeks during hot weather. Application of diquat to the flowing stream at the rate of 20 to 28 ppm will control all submerged plants in this area for a period of 6 to 8 weeks on each treatment.

In using 1.0 gal/cfs of socal-diquat or straight diquat on long ditches having clear water and a moderate growth of aquatic weeds, it was noted that the chemical was effective for approximately 1.0 mile. Diquat is inactivated by soil particles so the effectiveness of this chemical will depend on the water quality (turbidity from soil particles).

Several incomplete experiments point to the possibility of dropping the concentration of diquat to 18 ppm and still obtaining satisfactory plant control. This chemical was not found to be harmful to fish in this experiment in concentrations up to 27 ppm. Diquat controlled the algae during treating for submerged vegetation and no other chemical affected algal growth.

Socal, being highly toxic to aquatic life, could be used in concentrations up to 150 ppm, but the point of injection would have to be at least 2 miles from the discharge.

Dichlobenil is most effective when applied during the dormant season. This chemical can be applied on dry or moist areas, in ponds, lakes, or on areas with slow moving water. Dry areas should be treated during a period when water is available to moisten the chemical. In most of the drainage systems in this study, the flow of water is too fast for dichlobenil to be effective. In areas of moderate flow, the percolating effect washes the chemical from the soil and reduces the overall effectiveness.

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The Effects Of A 2,4-D Application On The Biota And Water Quality In Currituck Sound, North Carolina[1]

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ABSTRACT

On June 4, 1968 an application of a 20% (acid equivalent) formulation of the butoxyethanol ester of (2,4-dichlorophenoxy)acetic acid (2,4-D) herbicide was conducted to 200 acres of Eurasian watermilfoil (*Myriophyllum spicatum* L.) in Currituck Sound, North Carolina. No acute adverse effects on fish and other organisms were observed. No water samples contained residues exceeding 0.10 ppm. Reduction of Eurasian watermilfoil was estimated at 95% and subsequent re-establishment of native plants was considered to be of significant benefit to waterfowl. It is conceivable that reinfestation by Eurasian watermilfoil could have been reduced and possibly prevented through total treatment of the Sound.

INTRODUCTION

Severe infestation of important fish and wildlife habitats by obnoxious aquatic plants has become a concern of agencies interested in the use and development of these water resources. Such plant infestations seriously curtail fish and shellfish production, crowd out desirable waterfowl food plants, impede recreational uses, promote excessive siltation and greatly reduce the value and public use of the water areas.

The infestation and rapid spread of Eurasian watermilfoil over the past 10 years, during which time it has invaded and become established in many thousands of acres of eastern inland waters, has been studied extensively, but application of control measures has had limited success.

This aggressive plant grows in dense stands that completely dominate the aquatic flora and seriously affect fisheries and wildlife in some of our most productive estuaries. Eurasian watermilfoil now has been reported from 18 states. It occurs on at least 7 of the 43 coastal National Wildlife Refuges. The most extensive infestation is in Chesapeake Bay which is an important habitat for valuable commercial fish and shellfish. Many of the areas which have become infested with Eurasian watermilfoil are among the heaviest producers of recreational fishing.

The Natural Resources Institute of the University of Maryland examined a 340 square mile area of Chesapeake Bay, centering on the Bay Bridge, in the summer of 1962. The survey found that the area supported 230,000 angling trips (1.1 per acre) and estimated the taking of 1,751,000 fish weighing about 1,807,000 pounds. The catch consisted of 22 species about one-half of which was perch and one-quarter striped bass. Residue studies of shellfish where 2,4-D was used for Eurasian watermilfoil control indicate that shellfish, including oysters and soft-shelled clams, accumulate and lose 2,4-D related to the treatment. If shellfish are to be harvested from a treated area, a waiting period of 2 to 3 months is recommended (6).

Currituck Sound. Eurasian watermilfoil was first reported in North Carolina in 1959 at the Pea Island National Wildlife Refuge south of Currituck Sound. In 1962 this plant was eliminated by the intrusion of sea water and did not become a problem. First reports of Eurasian watermilfoil in Currituck Sound were made in the summer of 1965, but positive identification was not made until October of that year. There were approximately 100 acres in an infestation stage as a loosely woven blanket several feet thick. Approximately 500 to 1,000 additional acres contained the plant to some degree. By the summer of 1966, rapid spread of Eurasian watermilfoil resulted in an estimated 8,000 acres of heavy infestation, and the plant was established in an additional 67,000 acres.

Treatment Areas. Currituck Sound covers an area of approximately 97,000 surface acres. Average water depth is 5.4 ft with more than 80% less than 7 ft Eurasian watermilfoil was generally distributed over the area at the beginning of the experiment. For purposes of this study four 50-acre areas infested by Eurasian watermilfoil were selected for treatment: a. Swan Island-No. 1; b. Raccoon Bay-No. 2; c. Lighthouse Bay-No. 3; d. Parkers Creek-No. 4.

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[2]Deceased.